Estimation of Economic Burden of Cholera in Africa

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DEDICATION

I dedicate this work to my family for their patience, understanding, encouragement, prayers, and support during my stay away from home as I pursued the studies.

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GLOSSARY

CFR – Case fatality ratio

DALYs – Disability Adjusted Life Years

GAVI – Global Alliance for Vaccine and Immunization

GDP – Gross Domestic Product

GTFCC – Global Task Force on Cholera Control

ICG – International Coordinating Group

IHME – Institute for Health Metrics and Evaluation

LE – Life Expectancy

LMIC – Low and Middle Income Countries

OOP – Out-of-Pocket

OVC – Oral Cholera Vaccine

UNICEF – United Nations International Children's Fund

WASH – Water Sanitation and Hygiene

WHO – World Health Organization

ABSTRACT

The burden of disease for cholera remains high especially in low and lower middle income countries. Africa is the most affected by the disease among countries in this category. Severe outbreaks and persistent endemicity with high case fatality ratio (CFR) continue to rock the continent due to poor water and sanitation conditions. The outbreaks are also a result of prevailing internal and regional conflicts resulting to numerous Internally Displaced Persons (IDPs) and refugee camps which lack sufficient sanitation facilities. The epidemics are also attributable to perennial droughts and flooding during the rainy season in the region. Out of the 172,464 cholera cases reported to the WHO in 2015, the Africa region accounted for 55.8%. This study aims to estimate the economic burden of cholera in Africa in order for the respective countries to be appraised on the levels of preparedness that they require to put in place as well as allocate more resource in cholera prevention programs.

This was expressed by evaluating economic burden inputs such as cost of treatment borne by facilities, out-of-pocket expenditure, loss of productivity borne by individual families, from both patients and caregivers and cost effectiveness of interventions. The countries were classified by income level and based on the WHO mortality stratum. Reported cholera cases used in this analysis were derived from WHO reports in 2015. However, due to under-reporting by some countries due to fear of negative economic impact, cases estimated by a 2015 study on cholera burden by Ali et al were also utilized.

Our analysis included 44 African countries where it was estimated to have a total of 1,756,703 cholera cases and 66,416 deaths in 2015. In contrast, the WHO cholera report documented 16 countries with 71,176 cases and 937 deaths in Africa. Through this analysis we estimated $74.4 million (I$186.4 million) in out-of-pocket expenditure, US$104.2 million (I$258.2 million) in public health sector costs and $54.0 million (I$131.9 million) in lost productivity of patients and caregivers. Lost productivity due to premature death due to cholera was estimated to be $1.6 billion (I$4.1 billion). The total economic burden of cholera in Africa was estimated at $1.9 billion (I$4.6 billion).

Information on the estimation of the economic burden of cholera will give policy makers insight to make informed decisions in regard to prevention, detection, response and control of the disease.

INTRODUCTION

Cholera, an acute, diarrheal illness caused by infection of the intestine with the toxigenic bacterium Vibrio cholerae serogroup O1 or O139 [1], is one of the largest diarrheal illnesses in Africa due to poor water, sanitation and hygiene (WASH) conditions [2].

Globally it is estimated that 2.8 million cholera cases occur annually in cholera endemic countries and 1.4 billion people are at risk. It is also estimated that 91,000 people die of the disease every year [3]. In 2015 172,454 worldwide cases were reported to the World Health Organization (WHO) of which 1,304 resulted in death [2]

Table 1: Cholera case and deaths reported to WHO in 2015

Region	Cases	Deaths
Africa	71,176	937
Asia	64,590	30
Europe	22	0
America	36,664	337
Oceania	2	0
Total	**172,464**	**1304**

African countries continue to experience cholera outbreaks over the years despite a concerted effort by their respective departments of health to curb the menace. This has resulted in a negative impact on the economies of these countries due to the high costs involved in the prevention, detection and response to these outbreaks [4]. While several studies have been done in various countries on economic burden of cholera, cost-effectiveness of interventions among other areas of interest, there is a lack of an updated study to estimate the economic burden in Africa looking into the areas of loss of productivity, hospitalization and outpatient costs. Diarrheal diseases, under which cholera is classified, are according to the World Health Organization (WHO) ranked as the number two leading cause of premature deaths in low income countries [5].

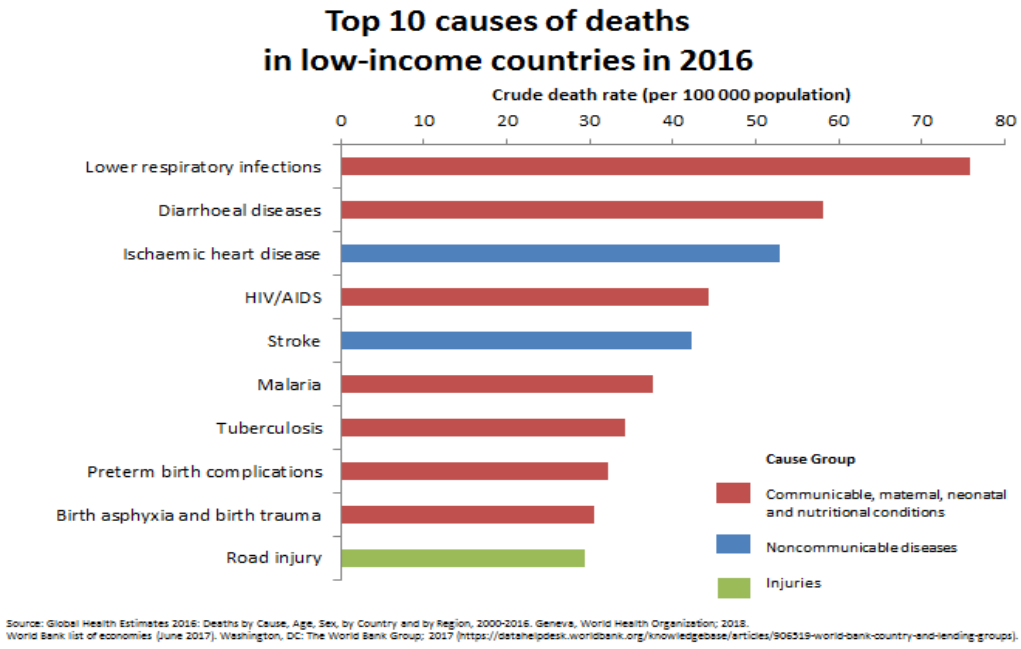

Figure 1: Burden of disease for AFR region *Source:WHO*

Sub-Saharan Africa, according to Amber Hsiao et al, accounts for 60% of cholera cases. It would be necessary therefore, to determine the economic burden for purposes of planning interventions [3]. Our study aims to estimate the economic burden of cholera in Africa in order for the respective countries to appraise the level of preparedness as well as allocate more resource in cholera prevention programs and enable the readiness of managers to handle outbreaks effectively.

Table 2: Cholera cases reported to the WHO in 2015 from the AFR region. *Source: WHO*

Country	**Cases**	**Deaths**	**CFR**
Burundi	442	0	00
Cameroon	124	6	4.8
Cote d'voire	199	6	3.0
Congo DR	19,182	276	1.4
Ghana	692	8	1.2
Kenya	13,292	67	0.5
Malawi	693	11	1.6
Mozambique	8,739	64	0.7
Niger	51	4	7.8
Nigeria	5,290	186	3.5

Country	Cases	Deaths	CFR
Somalia	7,536	84	1.1
South Sudan	1,818	47	2.6
Tanzania	11,563	144	1.2
Togo	35	1	2.9
Uganda	1,461	33	2.3
Zimbabwe	60	0	0.0
Total	**71,176**	**937**	**1.3**

Literature review

This section involves identifying the existing estimations of cost of illness and economic burden of cholera which will serve as the basis of this study by considering what other writers have contributed to the area of study. We will also provide a summary of the gaps identified in the studies at the end of the chapter.

Economic burden of disease

Morbidity and mortality are key considerations in estimating the economic burden of disease in populations, however it is not a reliable way of depicting the adverse impact caused by ill-health to human welfare, especially the economic consequences. According to the WHO, to be able to determine the economic consequences of disease or injury, we

must look at microeconomic level of households, firms or governments as well as the macroeconomic level which include the aggregate impact of a disease on a country's current and future gross domestic product (GDP) [6]. Joses M Kirigia et al for example did a study whose objective was to estimate the direct and indirect cost of cholera in the WHO African Region [4]. They estimated that about 178,677 cases of cholera and 4,033 cholera deaths were notified to the WHO in 2007, of which 62% cases and 56.7% deaths were reported from the WHO African Region.

The study used standard cost-of illness methods to estimate: (a) the direct costs, i.e. those borne by the health-care system and the family in directly addressing cholera; and (b) the indirect costs, i.e. loss of productivity caused by cholera, which is borne by the individual, the family or the employer and was based on the number of cholera cases and deaths notified to the WHO [4].

This study indicates that the economic burden of cholera in Africa was estimated to have an economic loss of US$39million, US$53.2million and US$64.2million using regional life expectancies of 40, 53 and 73 respectively [4].

Another study aimed to assess the costs of cholera illness and determine the cost-effectiveness of the 2016 vaccination campaign in Zambia in 2006. This was following the introduction of a Shancol—an oral cholera vaccine (OCV) campaign by the Zambian Ministry of Health in response to a cholera outbreak [7].

A recent study has been done on economic burden of cholera in Asia. According to the study out-of-pocket expenditure was estimated at US$20.2 million (I$74.4 million),

public sector cost of about US$8.5 million (I$30.1 million), loss of productivity due to illness was estimated at $12.1 million (I$43.7 million) and lost productivity due to premature deaths was estimated to be $985.7 million (I$3,638.6 million) [8]. Since Africa and Asia do not have the same social economic characteristics, this study will provide more insight into comparing the situations in Asia and Africa on the economic burden of cholera.

In another previous study conducted in Ghana, Dziedzom K.A et al did a household cost analysis and concluded that low income areas bear a higher household economic impact during cholera outbreaks [9]. Most African countries are in the category of low income and therefore our study will put into perspective the economic burden of cholera in the continent.

Interventions

To prevent and control cholera and to reduce cholera-related deaths a multifaceted approach is used. This includes surveillance, water, sanitation and hygiene, social mobilization, treatment, and oral cholera vaccines among others control measures[10].

Surveillance

Information sharing at the global level and feedback at the community level should be used in integrated disease surveillance which include cholera surveillance.

Detection of cholera cases is usually based on clinical suspicion in patients that present with watery diarrhea. Stool samples from affected patients are then tested for V. cholerae to confirm the suspicion. An effective surveillance system requires local laboratory

capacity in order to diagnose and monitor cholera occurrence which will be vital in planning for control measures.

Cross border surveillance should be strengthened especially in countries that neighbour cholera affected areas to prevent the spread of the disease across borders and enhance national preparedness to rapidly detect and respond to any eventualities.

Although notification of all cases of cholera is no longer mandatory under the International Health Regulations, public health events involving cholera must always be assessed against the criteria provided in the regulations to determine whether there is a need for official notification [10].

Vaccination

In their study aims at estimating the cost-of-illness of cholera to households and health facilities in Machinga and Zomba Districts Malawi, IIbuodo PG, et al conducted a cross-sectional study using retrospectively collected cost data. In the study it is noted that the average costs to patients' households and health facilities for treating an episode of cholera was US $65.6 and US$59.7 in 2016 for households and health facilities, respectively which was equivalent to 249.9 and 227.5 international dollars(I$). Costs incurred in treating a cholera episode were proportional to duration of hospital stay. Also, 52% of households used coping strategies to compensate for direct and indirect costs imposed by the disease. Broader use of pre-emptive cholera vaccination could avert significant treatment expenditures incurred by households and health facilities through.

These findings have direct policy implications regarding priority investments for the prevention and control of cholera [11].

Oral cholera vaccines (OCVs)

There are three oral cholera vaccines that are currently pre-qualified by WHO. These are Dukoral®, Shanchol™, and Euvichol®. For full protection all 3 vaccines require 2 doses [10].

Dukoral® is administered with a buffer solution that, for adults, requires 150 ml of clean water. It is therefore recommended for travelers as access to clean water is often limited in areas with cholera epidemics. Dukoral® provides about 65% protection against cholera for 2 years [10]. The other two vaccines Shanchol™ and Euvichol® are essentially similar vaccine from two different companies. Since they do not require a buffer solution to administer, they are recommended for use in emergencies where many people need to be vaccinated. 1 dose of vaccine will provide some protection with the second dose given at a later date A minimum of a two-weeks delay between each dose of these 2 vaccines must be allowed. [10].

The vaccine gives approximately 65% protection against cholera for up to 5 years to vaccinated individuals. Herd protection is also attained through the reduction of V. cholerae bacteria circulation in the population as a result of vaccination in endemic areas. [10].

The WHO has established a stockpile of 2 million doses for use in outbreak control and emergencies since 2013. The stockpile is managed by the International Coordinating

Group (ICG) made up of the International Federation of Red Cross and Red Crescent Societies, Medecins Sans Frontieres, UNICEF, and WHO [10].

For non-emergency settings, vaccines are available via the Global Task Force on Cholera Control (GTFCC). In these contexts, oral cholera vaccines are used as part of a longer-term cholera control plan including reinforcement of other aspects of cholera control such as improvements in water and sanitation. In eligible countries, financial support for vaccines is provided by Gavi, the Vaccine Alliance (GAVI) [10].

More than 5 million doses of OCVs have been used in mass vaccination campaigns with WHO support. The campaigns have been implemented in areas experiencing an outbreak in areas at heightened vulnerability during humanitarian crises, and among populations living in highly endemic areas, known as “hotspots” [10].

The use of OCVs has enabled the collection of evidence on and demonstration of the effectiveness and feasibility of implementing OCV campaigns as a public health tool, protecting populations at high risk of cholera [10].

WASH

Economic development and universal access to safe drinking water and adequate sanitation facilities offers long-term solution for cholera control. Implementation of sustainable WASH solutions in cholera hotspots are important actions targeting environmental conditions. Other than cholera, these WASH measures prevent a wide range of other water-borne illnesses, as well as aiding to achieve goals related to poverty,

malnutrition, and education. WASH goals are anchored in many ways to the targets of the Sustainable Development Goals (SDGs) [10].

SDG goal number six aims to "ensure availability and sustainable management of water and sanitation for all" UNICEF has undertaken three main targets under WASH: (a), to achieve universal and equitable access to safe and affordable drinking water for all by the year 2030. (b), to achieve adequate and affordable access to proper sanitation and hygiene and end open defecation and paying special attention to the needs of girls and women in vulnerable situations by 2030, and (c), improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally by the year 2030 [12].

Treatment

Cholera can be treated easily through prompt administration of oral rehydration solution (ORS). The WHO/UNICEF ORS standard sachet is dissolved in 1 litre (L) of clean water. Adult patients may require up to 6 L of ORS to treat moderate dehydration on the first day [10].

Rapid administration of intravenous fluids is required for severely dehydrated patients who are at risk of shock. For example, an adult who weighs 70 kg will require at about 7 litres of intravenous fluid, in addition to ORS during the treatment. Antibiotics are also given appropriately to reduce the duration of diarrhea, reduce the volume of

rehydration fluids needed, as well as to shorten the amount and duration of *V. cholerae* excretion in their stool [10].

Health care givers are generally discouraged from mass administration of antibiotics because it has no known impact and increases the problem of antimicrobial resistance. Access to treatment during cholera outbreak is critical and oral rehydration should be made available to the communities as well as providing intravenous fluids and other essential services on a 24-hour basis. Case fatality ratio (CFR) should remain below 1% with proper and early treatment [10].

Hygiene promotion and social mobilisation

Health promotion that is in tandem with local culture and beliefs, should advocate the adoption of proper hygiene practices including hand-washing with soap, safe food handling and storage and proper disposal of faecal waste. To prevent attendees of funeral rituals and burial ceremonies from contracting cholera, proper infection prevention and control measures must be put in place [10].

Sensitization campaigns should be planned during cholera outbreaks with clear information provided to the community concerning the potential risks and general information about cholera including the symptoms and precautionary measures to take to avoid cholera, relevant authorities to report to and where to seek immediate treatment when symptoms appear. [10]

Justification

Africa especially Sub-Saharan is marred with conflicts, acute water shortages during drought and flooding during rainy seasons. These conditions escalate the cholera problem in the region. For example in 2008, a cholera outbreak with unusually high mortality occurred in Kenya following tribal clashes after the results of a disputed presidential election [13].According to the WHO, cholera cases reported from Kenya increased exponentially over the years. [14].

In Garissa County an outbreak occurred in April 2017 and later in nine other counties (Nairobi, Murang'a, Vihiga, Mombasa, Turkana, Kericho, Nakuru, Kiambu, and Narok). These outbreaks occurred in the general population as well as in refugee camps such as Hagadera, Dadaab, Dagahaleh and Ifo 2 in Garrissa county and Kakuma and Kalobeyei refugee camps in Turkana county [14].

In Nairobi county cholera cases occurred interestingly among participants of a conference in a high end hotel and another outbreak occurred at a trade fair held at the Kenyatta International Convention Centre (KICC) where 146 and 136 cases respectively were reported as well as one death [14]. Since December 2014 until 2016, the Republic of Kenya has been experiencing continuous large outbreaks of cholera, with a cumulative total of 19,739 cases reported (13,291 cases reported in 2015 and 6,448 in 2016)[14].

In Zambia in May 2018, Cholera outbreaks occurred in 10 provinces following heavy flooding and widespread water shortages and as a result 5,905 suspected cases were

reported with a case fatality rate of 1.9%. Most of these cases (91.7%) were reported in the capital Lusaka [15].

These characteristics are similar in many other Sub-Saharan Africa countries and therefore estimating the economic burden of cholera in this region will be of paramount importance in order to plan interventions appropriately, keep policy-makers at all levels aware of the economic burden of cholera and aid in mitigation actions required during such outbreaks [3]

Study Purpose and Objectives

Purpose

The study aims to estimate the economic burden of cholera in Africa in a bid to advise countries and partnerships in their efforts for cholera control and elimination.

Objectives

- To determine the treatment cost borne by facilities
- To determine the out of pocket expenses
- To establish the loss of productivity borne by individual families (patients and caregivers) and its economic impact
- To determine loss of productivity due to death and its economic impact

METHOLOGY

Study design

This is a retrospective study focusing on 2015 cholera cases as reported to the WHO. Countries were classified according the mortality strata as defined by WHO-CHOICE (CHoosing Interventions that are Cost-Effective) [16].

Table 3: Epidemiological sub-regions for reporting results of WHO-CHOICE

Region	Mortality stratum	Countries
AFR	D	Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tome And Principe, Senegal, Seychelles, Sierra Leone, Togo
AFR	E	Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic Of The Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
EMR	D	Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen

Selection criteria

African countries were listed according to United Nations recognition [17]. Cholera cases reported by WHO weekly epidemiologic reports 2015 were analyzed [3]. A previous study by Mogasale et al classified countries in two groups such that countries who

reported cholera cases to the WHO in 2015 were put in one group and cholera reporting countries from the global burden of disease study by Ali et al were put in the other group. In the global burden of disease study, cholera endemicity was defined in terms of a spatial regression that predicts the occurrence of cholera in three of the previous five years [3].

Data source

For annual cholera cases and deaths, we used secondary data from WHO weekly epidemiological report of 2015 along with estimated annual cholera cases from the disease burden study by Ali et al.

Data on economic cost such as productivity loss, out-of-pocket cost and health system costs were obtained through a literature review conducted by Hsiao et al [2]. More recent articles from additional searches were also included.

GDP per capita were sourced from the World Economic Outlook (WEO) Reports by the International Monetary Fund (IMF). Data for life expectancy of each country were sourced from the World Bank database.

Conceptual framework

Figure 3 shows health services costs borne by facilities and out-of-pocket expenditure as the independent variables which in this case will determine the outcome of the study. Intervening variables are represented as loss of productivity by both patients and care givers as well as premature deaths. The dependent variable which is the outcome of the study is indicated as economic burden.

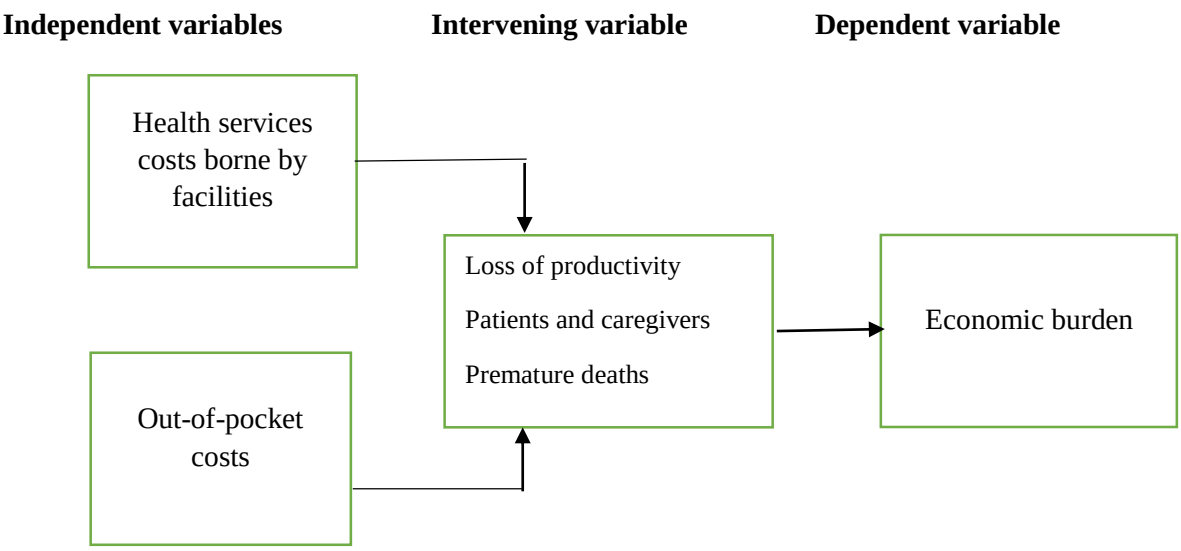

Figure 2: Conceptual Framework

Economic Costs

Input data to derive the economic costs of cholera are defined by the following: a) number of workdays lost due to cholera for patients and caregivers, b) hospitalization rates, c) cost-per-case for patients/households and the public health system for hospitalized cases and d) cost-per-case for patients/households and the public health system for out-patient cases. These data were extracted from previous studies on the economic cost of cholera. These studies were identified through a systematic review of the health economics of cholera conducted by Hsiao et al in 2018 [2]. Additionally, through searches on PubMed, two recent papers not included in the Hsiao (2018) study were included. Data was extracted from Ghana, Tanzania, Zambia, Malawi and Mozambique. Due to the limited availability

of the data, the mean value was extrapolated to all countries included in the analysis while taking under consideration gross domestic product per capita and the data uncertainty represented by confidence interval (CI).

Loss of productivity by patients and care givers

Loss of productivity due to illness was estimated based on the average lost work days of patients and caregivers during the duration of illness and recuperating period. Lost work days of patients and caregivers were recorded separately. Lost work days for Ghana, Malawi and Mozambique were extracted directly from their respective sources. Data from Tanzania only includes the duration of illness and does not account for loss of productivity during the recuperation period. While the study in Zambia did not give an exact average, we were able to estimate the average based on the survey results. The ranges of the lost-days were calculated based on the range derived from the study in Tanzania, where a variable of 20% was observed. The lost days were then multiplied by the average income per capita (GDP per capita).

Costs borne by health service delivery facilities

Service delivery costs were also extracted from the papers for each hospitalized and outpatient cases. Health service delivery costs include personnel, medicines, diagnostic tools, medical equipment, infrastructure, beds and utilities that patients are not responsible for paying. Each of the recorded costs was then converted to the worth of US dollars (US$) in 2015. For the conversion, the annual percent changes in world consumer prices as established by the IMF were applied.

Of the five countries used in this study, Malawi, Tanzania, and Mozambique reported health service delivery costs. For countries without reported costs, the outpatient service delivery cost estimated through the WHO-CHOICE project was used [18]. The WHO-CHOICE outpatient costs for each country was then multiplied by hospitalized and outpatient cases to estimate total service delivery costs.

Out-of-Pocket expenditure

Out-of-pocket (OOP) costs for hospitalized cases were reported for all five countries used in the study. For outpatient cases, only Malawi reported costs. OOP costs can be divided into direct medical and direct non-medical costs. Direct medical costs include expenditure accrued by patients for diagnosis, medicine and other costs directly related to the treatment of cholera. Direct non-medical costs include resources spent on travel to healthcare facility, room and boarding, food and other costs not immediately related to treatment. As with health service delivery costs, all costs were converted into the amount of US dollars in 2015. For countries that did not report either OOP costs for hospitalization or outpatient, the average cost derived from the rest of the reports costs were applied.

Loss of productivity as a result of death

To estimate the productivity loss due to premature death from cholera, the mean age of cholera incidence was derived from a previous study reporting the age distribution of cholera by WHO region. Life expectancy at birth for each country was subsequently subtracted by the mean age of cholera. Information for life expectancy used the 2015 data

provided by the World Bank [19]. In order to convert the years lost to monetary values, GDP per capita was multiplied by the number of deaths from cholera and the number of productivity years lost per death.

Hospitalization Rate

Only the study conducted in Malawi reported hospitalization rate, at 90% hospitalized and 10% receiving care for less than 12 hours, which is analogous to outpatient care. Other studies included in the analysis were unclear whether all cases were hospitalized or only hospitalized cases were accounted for. Since 90-100% hospitalization is considered to be highly unusual, the analysis was conducted based on three scenarios: (a) under the assumption of 90-100% hospitalization, (b) average of 75% hospitalization and (c) average of 55% hospitalization. Assumption (b) was determined based on a previous investment case study while assumption (c) was based on results from an economic burden study conducted for Asian countries.

Economic model

Based on a previous study (Mogasale et al) [8] we did uncertainty analysis using Ersatz an Epigear tool in which we used beta-PERT distribution for cost inputs [20]. This enabled us to get the minimum, mean and maximum input parameters. To estimate 95% CI, we used Monte Carlo simulation to conduct multivariate sensitivity analysis based on 5,000 random draws.

RESULTS

The average number of days with loss of income was 5.76 days for patients and 3.86 days for care givers. The proportion of cases hospitalized was about 98% which was slightly on the higher side. However, due to the fact that there were very few outpatient cases the high hospitalization rate was therefore admissible. Mean age of death due to cholera was 14.66 years. (Table 4)

Table 4: Input parameter assumptions used in uncertainty analysis

Input parameter	**Mean value**	**Minimum value**	**Maximum value**	**Source**
Number of days with loss of income — cholera cases	5.76 days	4.61 days	6.97 days	[2-4, 7, 9, 21]
Number of days with loss of income — caregivers	3.86 days	3.09 days	4.64 days	[2-4, 7, 9, 21]
Proportion of cases hospitalized	0.98	0.90	1.00	[2, 3, 11]
Public health service delivery costs for hospitalized cases	65.77 US$	39.83 US$	85.41 US$	[2, 3, 11]
Public health service delivery costs for outpatient cases	2.55 US$	1.54 US$	3.31 US$	[11]
Out-of-pocket costs to patient and family for hospitalization	38.87 US$	6.05 US$	109.94 US$	[2, 3, 9]
Out-of-pocket costs to patient and family for outpatient cases	5.71 US$	0.89 US$	16.15 US$	[2, 3, 9, 11]

Input parameter	Mean value	Minimum value	Maximum value	Source
Age of death due to cholera	14.66 years	1.00 year	75.00 years	[2-4, 9, 11, 21]

The following countries were included in the analysis Angola, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central Africa Republic, Chad, Comoros, Democratic Republic of Congo, Republic of Congo, Cote D'voire, Djibouti, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, São Tomé and Principe, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia and Zimbabwe **(Annex 2).**

Our analysis included 44 African countries where it was estimated to have a total of 1,756,703 cholera cases and 66,416 deaths in 2015. In contrast, the WHO cholera report documented 16 countries with 71,176 cases and 937 deaths in Africa. Through this analysis we estimated $74.4million (I$186.4million) in out-of-pocket expenditure, US$104.2million (I$258.2million) in public health sector costs and $54.0 million (I$131.9million) in lost productivity of patients and caregivers. The total economic burden of cholera in Africa was estimated at $1.9 billion (I$4.6billion)

Table 5: Economic burden of cholera in Africa

Economic burden	US$ 2015 (in millions)			I$ 2015 (in millions)		
	Mean	95%LCI	95%UCI	Mean	95%LCI	95%UCI
Lost productivity due to illness	$54.0	$40.1	$68.6	$131.9	$99.1	$166.3
Public health system costs	$104.2	$81.2	$126.0	$258.2	$202.9	$310.8
Out-of-pocket costs	$74.4	$31.0	$129.3	$186.4	$80.1	$321.0

Subtotal economic burden	**$232.6**	$178.4	$292.9	**$576.4**	$444.9	$723.4
Lost productivity due to premature deaths	$1,661.4	$534.1	$2,111.6	$4,072.6	$1,352.0	$5,159.6
Total economic burden	**$1,894.0**	$755.6	$2,350.5	**$4,649.0**	$1,903.2	$5,751.8

DISCUSSION

The total economic burden of cholera in Africa was estimated at $1.9 billion (I$4.6 billion). Lost productivity due to premature death due to cholera was estimated to be $1.7 billion (I$4.7 billion). Productivity loss due to premature death accounted for 87.7% of the total economic burden of cholera in Africa. Public health system costs accounted for 5.5%. 3.9% of the costs were regarded as out-of-pocket expenditure while loss of productivity due to illness took 2.9% of the total economic burden of cholera in Africa.

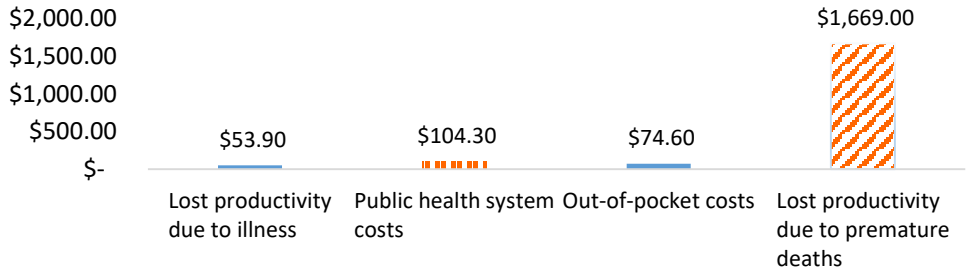

Figure 3: Economic burden of cholera in Africa (million $)

Results from a Spearman's rank correlation coefficient analysis showed which input parameter had the most effect on determining the economic burden estimates. The results showed that hospitalization costs, for both patient/families and healthcare providers, lost days in productivity for both patients and caregivers were among the most sensitive parameters in influencing economic burden due to cholera in Africa (Figure 4).

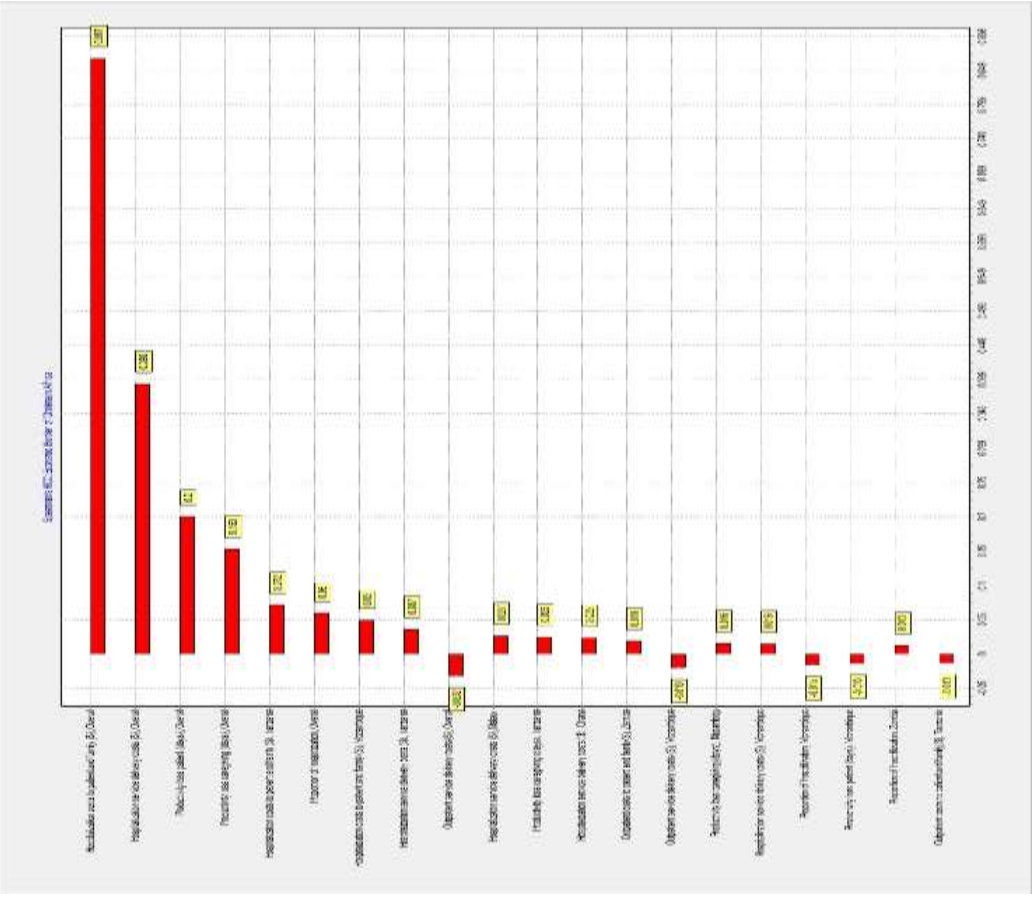

Figure 4: Spearman's RCC: Economic burden of cholera in Africa

We were able to estimate the economic burden of cholera in Africa as summarized in Table 5 below. Countries with high number of cases and deaths such as Nigeria, Ethiopia, Kenya, Congo DR and Tanzania have borne the brunt of the economic burden.

Table 6: Economic burden of cholera in Africa by country

Country*	**Productivity loss due to illness**	**Public health system cost**	**Out of pocket costs**	**Sub-total economic burden**	**Productivity loss due to premature deaths**	**Total economic burden**
Angola	$1,907,936	$1,033,150	$722,570	$3,663,657	$63,663,745	**$67,327,402**
Benin	$475,418	$1,037,422	$728,105	$2,240,945	$15,731,108	**$17,972,053**
Burkina Faso	$396,157	$1,617,053	$1,135,117	$3,148,327	$12,974,961	**$16,123,288**
Burundi	$156,692	$1,249,419	$877,534	$2,283,645	$4,912,055	**$7,195,700**
Cameroon	$751,298	$1,319,523	$925,672	$2,996,494	$23,724,394	**$26,720,887**
Cape Verde	$30,408	$23,909	$16,735	$71,053	$1,149,374	**$1,220,427**
Central Africa Rep.	$108,400	$719,739	$505,311	$1,333,450	$3,049,372	**$4,382,822**
Chad	$515,200	$1,278,610	$897,386	$2,691,197	$14,854,844	**$17,546,041**
Comoros	$29,388	$54,820	$38,473	$122,682	$1,009,791	**$1,132,472**
Congo, Democratic Republic	$2,199,097	$11,845,306	$8,319,083	$22,363,486	$71,256,767	**$93,620,253**
Congo, Rep.	$743,759	$847,378	$593,431	$2,184,568	$25,757,376	**$27,941,945**
Cote d'voire	$2,150,595	$3,618,265	$2,538,438	$8,307,297	$62,606,414	**$70,913,711**
Djibouti	$46,211	$42,894	$30,093	$119,198	$1,316,422	**$1,435,620**
Eritrea	$205,069	$1,367,084	$959,968	$2,532,122	$7,146,892	**$9,679,013**
Ethiopia	$5,160,241	$17,246,028	$12,110,309	$34,516,578	$180,691,570	**$215,208,148**
Gabon	$414,659	$131,774	$91,759	$638,192	$14,629,121	**$15,267,313**
Gambia, The	$18,639	$67,413	$47,329	$133,381	$619,459	**$752,840**
Ghana	$2,357,375	$2,657,060	$3,177,763	$8,192,198	$66,230,704	**$74,422,902**
Guinea	$338,850	$1,117,790	$784,866	$2,241,506	$11,018,939	**$13,260,445**
Guniea-Bissau	$43,618	$159,098	$111,721	$314,438	$1,358,111	**$1,672,549**
Kenya	$4,314,404	$6,976,265	$4,896,247	$16,186,916	$153,926,535	**$170,113,450**
Lesotho	$185,056	$372,789	$261,637	$819,481	$5,463,085	**$6,282,565**
Liberia	$132,378	$406,704	$285,618	$824,699	$4,469,317	**$5,294,016**
Madagascar	$382,756	$2,245,972	$1,576,816	$4,205,543	$13,483,932	**$17,689,475**
Malawi	$342,005	$2,100,790	$781,796	$3,224,591	$9,436,103	**$12,660,694**
Mali	$449,747	$1,367,772	$960,038	$2,777,557	$14,184,155	**$16,961,712**
Mauritania	$185,771	$335,007	$235,059	$755,837	$6,351,655	**$7,107,492**
Mozambique	$1,013,895	$3,667,667	$2,860,265	$7,541,826	$35,119,696	**$42,661,522**
Namibia	$815,978	$372,762	$260,801	$1,449,541	$28,116,023	**$29,565,564**
Niger	$279,929	$1,812,768	$1,272,849	$3,365,546	$9,131,648	**$12,497,194**

Country*	Productivity loss due to illness	Public health system cost	Out of pocket costs	Sub-total economic burden	Productivity loss due to premature deaths	Total economic burden
Nigeria	$16,031,073	$13,827,223	$9,697,933	$39,556,229	$466,078,145	**$505,634,374**
Rwanda	$383,218	$1,222,526	$858,305	$2,464,050	$13,669,360	**$16,133,409**
São Tomé and Principe	$11,055	$16,559	$11,617	$39,230	$392,291	**$431,521**
Senegal	$393,710	$779,750	$547,078	$1,720,538	$14,047,847	**$15,768,385**
Sierra Leone	$160,091	$627,155	$440,373	$1,227,619	$4,501,181	**$5,728,799**
Somalia	$95,277	$763,337	$535,462	$1,394,076	$2,460,402	**$3,854,478**
South Sudan	$961,824	$1,845,870	$1,294,762	$4,102,456	$29,752,181	**$33,854,637**
Sudan	$1,960,158	$2,714,443	$1,903,839	$6,578,441	$57,284,871	**$63,863,312**
Swaziland	$206,919	$128,849	$90,292	$426,060	$6,488,561	**$6,914,620**
Tanzania	$3,725,986	$10,830,527	$4,435,003	$18,991,516	$143,216,936	**$162,208,452**
Togo	$165,027	$687,795	$482,791	$1,335,614	$5,407,547	**$6,743,161**
Uganda	$1,548,561	$5,623,684	$3,948,133	$11,120,379	$50,464,551	**$61,584,929**
Zambia	$999,924	$1,726,815	$625,837	$3,352,577	$32,148,903	**$35,501,480**
Zimbambwe	$1,193,214	$1,968,631	$1,381,006	$4,542,850	$39,360,526	**$43,903,376**
Total	**$53,986,967**	**$109,855,395**	**$74,255,223**	**$238,097,584**	**$1,728,656,868**	**$1,966,754,452**

Limitations of the study

The study has a number of limitations including the following:

1) Insufficient data – most countries under reported or had not reported cholera cases to the WHO at all and therefore we extrapolated data from the countries that reported to the WHO in 2015 based on the assumption that the trends were the same across Africa. Therefore, this could result in underestimation of the economic burden.
2) Hospitalization rate – Hospitalization rate which directly influenced hospitalization costs for both patients and caregivers was unusually high which would pendulum the economic burden due to cholera to the upward trajectory. Thus scenario analysis was done (we used scenario 1) to determine the lowest discounted cost estimates using the WHO reported cholera cases and deaths.

Conclusion

Using Monte Carlo simulation economic model, we estimated the total economic burden of cholera in Africa at $1.9 billion. The brunt of the economic burden was borne by productivity loss due to premature death, resultant from the low mean age of cholera death of 14.66 years. The countries that bears the greatest of the economic burden of cholera are Nigeria, Ethiopia, Kenya, Congo DR and Tanzania. We recommend these countries to engage decisively in evidence based research on which cholera control interventions would be most appropriate for them and allocate more resources towards cholera prevention strategies.

Abstract in Korean

전세계적으로 콜레라에 대한 질병의 부담이 지속되고 있으며 이는 저소득 국가들에서 꾸준히 높게 나타나고 있으며 특히 아프리카에서 가장 많은 영향을 받고있다. 높은 사망률 (case fatality ratio, CFR)을 수반한 고질적이고 심각한 발병은 열악한 물과 위생환경으로 인해 본 대륙을 지속적으로 뒤흔들고 있다. 이러한 발병은 만연한 내부 및 지역간 갈등으로 인해 수많은 난민들과 충분한 위생시설이 부족한 난민촌의 환경에 의해 발생한다. 또한 장마철에 따른 가뭄과 홍수에 의해 발병이 되기도 한다. 2015 년 세계보건기구 (World Health Organization, WHO) 에 보고된 콜레라 환자 17 만 2464 명 가운데 아프리카 지역이 55.8%를 차지했다. 본 연구는 콜레라 발병 국가의 콜레라 예방 프로그램에 더 많은 자원을 할당할 뿐 아니라, 콜레라 예방 프로그램을 시행하기 위해 필요한 준비 수준을 평가하기 위해 아프리카 내 콜레라의 경제적 부담을 추산하는 것을 목표로 한다.

이를 위해 의료시설 부담 치료 비용, 환자 또는 가족 부담 치료비, 환자본인 및 간병인의 생산성 손실과 치료의 비용효과성과 같은 경제적 입력변수를 평가한다. 연구에 포함된 국가들은 소득별 및 WHO 의 사망층으로 구분되었다. 콜레라 발병사례는 2015 년에 WHO 에 보고된 수치를 사용하였다. 그러나 부정적인 경제적 영향을 우려하여 과소신고 될 수 있는 점을 감안하여 2015 년에 발표된 Ali 외 연구진의 콜레라 질병부담 연구 결과도 사용하였다.

연구결과 2015 년 총 175 만 6703 명의 발병자와 6 만 6416 명의 사망자가 44 개 아프리카 국가에서 집계되었다. 대조적으로, WHO 콜레라 보고서는 아프리카에서 71,176 명의 발병자와 937 명의 사망자를 16 개국에서 기록했다. 이 분석을 통해

환자 부담 비용 금액이 미화 7,440 만 달러, 공공 의료 부문 비용은 1 억 420 만 달러, 환자와 간병인의 생산성 손실을 5,400 만 달러로 추산했다. 또한 콜레라에 의한 조기 사망으로 인한 생산성 손실은 약 17 억 달러로 추산되었다. 전체 경제적 부담금액은 약 19 억 달러로 추산되었다.

본 연구와 같은 콜레라 경제적 부담의 추정에 관한 연구로 인해 정책 입안자들에게 질병의 예방, 탐지, 대응, 통제와 관련하여 정보에 입각한 결정을 내릴 수 있는 도구가 될 것으로 예상된다.

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ANNEXES

Annex 1: COUNTRY CLASSIFICATION

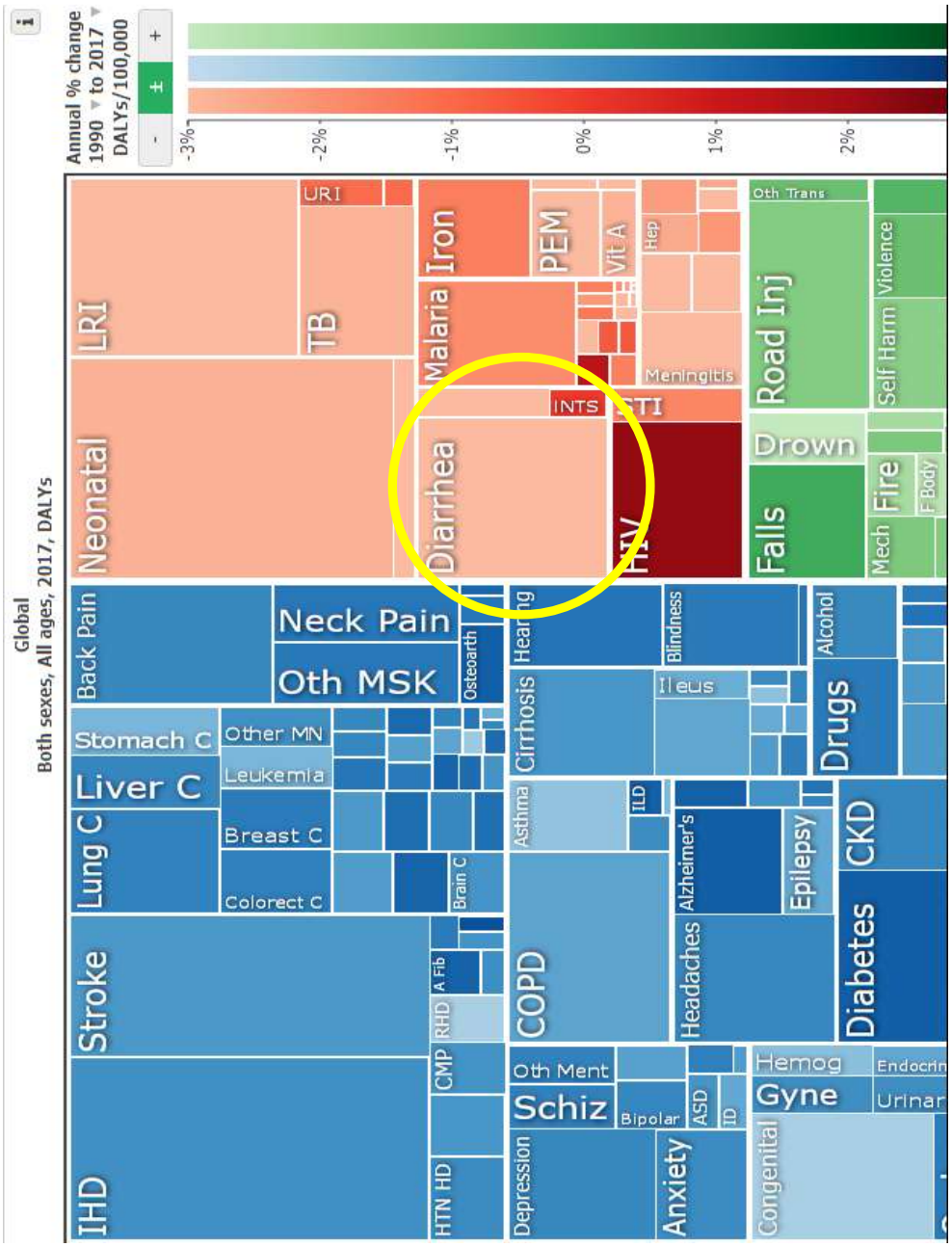
ISO	Country	Region	Sub-region	WHO Stratum	Sanitation MDG Progr	Water MDG Progre	Economic Classification
AFG	Afghanistan	Asia	Southern Asia	EMR-D	Limited or no progress	Good progress	LOW-INCOME ECONOMIES ($995 OR LESS)
AGO	**Angola**	**Africa**	**Middle Africa**	**AFR-D**	**Good progress**	**Limited or no progress**	**LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)**
BGD	Bangladesh	Asia	Southern Asia	SEAR-D	Good progress	Met target	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
BEN	Benin	Africa	Western Africa	AFR-D	Limited or no progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
BFA	Burkina Faso	Africa	Western Africa	AFR-D	Limited or no progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
BDI	Burundi	Africa	Eastern Africa	AFR-E	Limited or no progress	Moderate progress	LOW-INCOME ECONOMIES ($995 OR LESS)
CMR	Cameroon	Africa	Middle Africa	AFR-D	Limited or no progress	Met target	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
TCD	Chad	Africa	Middle Africa	AFR-D	Limited or no progress	Moderate progress	LOW-INCOME ECONOMIES ($995 OR LESS)
COD	**Congo, Dem. Rep.**	**Africa**	**Middle Africa**	**AFR-E**	**Limited or no progress**	**Limited or no progress**	**LOW-INCOME ECONOMIES ($995 OR LESS)**
COG	Congo, Rep.	Africa	Middle Africa	AFR-E	N/A	N/A	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
CIV	Côte d'Ivoire	Africa	Western Africa	AFR-E	Limited or no progress	Moderate progress	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
DJI	Djibouti	Africa	Eastern Africa	EMR-D	N/A	N/A	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
DOM	Dominican Republic	Americas	Caribbean	AMR-B	Met target	Met target	UPPER-MIDDLE-INCOME ECONOMIES ($3,896 TO $12,055)
ERI	Eritrea	Africa	Eastern Africa	AFR-E	Moderate progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
ETH	Ethiopia	Africa	Eastern Africa	AFR-E	Met target	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
GHA	**Ghana**	**Africa**	**Western Africa**	**AFR-D**	**Met target**	**Limited or no progress**	**LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)**
GIN	Guinea	Africa	Western Africa	AFR-D	Limited or no progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
GNB	Guinea-Bissau	Africa	Western Africa	AFR-D	Good progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
HTI	Haiti	Americas	Caribbean	AMR-D	Met target	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
IND	India	Asia	Southern Asia	SEAR-D	Good progress	Met target	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
IRN	Iran, Islamic Rep.	Asia	Southern Asia	EMR-B	Met target	Good progress	UPPER-MIDDLE-INCOME ECONOMIES ($3,896 TO $12,055)
IRQ	**Iraq**	**Asia**	**Western Asia**	**EMR-D**	**Limited or no progress**	**Limited or no progress**	**UPPER-MIDDLE-INCOME ECONOMIES ($3,896 TO $12,055)**
KEN	**Kenya**	**Africa**	**Eastern Africa**	**AFR-E**	**Moderate progress**	**Good progress**	**LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)**
LBR	Liberia	Africa	Western Africa	AFR-D	Limited or no progress	Good progress	LOW-INCOME ECONOMIES ($995 OR LESS)
MWI	Malawi	Africa	Eastern Africa	AFR-E	Moderate progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
MYS	**Malaysia**	**Asia**	**Southeastern Asia**	**Wpr-B**	**Met target**	**Met target**	**UPPER-MIDDLE-INCOME ECONOMIES ($3,896 TO $12,055)**
MLI	Mali	Africa	Western Africa	AFR-D	Limited or no progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
MOZ	**Mozambique**	**Africa**	**Eastern Africa**	**AFR-E**	**Met target**	**Good progress**	**LOW-INCOME ECONOMIES ($995 OR LESS)**
MMR	**Myanmar**	**Asia**	**Southeastern Asia**	**SEAR-D**	**Limited or no progress**	**Moderate progress**	**LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)**
NAM	Namibia	Africa	Southern Africa	AFR-E	Met target	Met target	UPPER-MIDDLE-INCOME ECONOMIES ($3,896 TO $12,055)
NPL	Nepal	Asia	Southern Asia	SEAR-D	Limited or no progress	N/A	LOW-INCOME ECONOMIES ($995 OR LESS)
NER	Niger	Africa	Western Africa	AFR-D	Good progress	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
NGA	**Nigeria**	**Africa**	**Western Africa**	**AFR-D**	**Limited or no progress**	**Good progress**	**LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)**
PAK	Pakistan	Asia	Southern Asia	EMR-D	Limited or no progress	Met target	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
PNG	Papua New Guinea	Oceania	Melanesia	Wpr-B	Met target	Good progress	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
PHL	**Philippines**	**Asia**	**Southeastern Asia**	**Wpr-B**	**Met target**	**Met target**	**LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)**
SLE	**Sierra Leone**	**Africa**	**Western Africa**	**AFR-D**	**N/A**	**N/A**	**LOW-INCOME ECONOMIES ($995 OR LESS)**
SOM	Somalia	Africa	Eastern Africa	EMR-D	N/A	N/A	LOW-INCOME ECONOMIES ($995 OR LESS)
SSD	South Sudan	Africa	Eastern Africa		Met target	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
SDN	**Sudan**	**Africa**	**Northern Africa**	**EMR-D**	**N/A**	**N/A**	**LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)**
TZA	Tanzania	Africa	Eastern Africa	AFR-E	Met target	Limited or no progress	LOW-INCOME ECONOMIES ($995 OR LESS)
THA	Thailand	Asia	Southeastern Asia	SEAR-B	Limited or no progress	Limited or no progress	UPPER-MIDDLE-INCOME ECONOMIES ($3,896 TO $12,055)
TGO	Togo	Africa	Western Africa	AFR-D	Limited or no progress	Good progress	LOW-INCOME ECONOMIES ($995 OR LESS)
UGA	Uganda	Africa	Eastern Africa	AFR-E	N/A	Met target	LOW-INCOME ECONOMIES ($995 OR LESS)
YEM	**Yemen, Rep.**	**Asia**	**Western Asia**	**EMR-D**	**N/A**	**N/A**	**LOW-INCOME ECONOMIES ($995 OR LESS)**
ZMB	Zambia	Africa	Eastern Africa	AFR-E	Limited or no progress	Moderate progress	LOWER-MIDDLE-INCOME ECONOMIES ($996 TO $3,895)
ZWE	**Zimbabwe**	**Africa**	**Eastern Africa**	**AFR-E**	**Limited or no progress**	**Limited or no progress**	**LOW-INCOME ECONOMIES ($995 OR LESS)**

Annexes 2: GDP per capita in USD 2015

Country	GDP per capita in USD 2015	GDP per capita in INT 2015
Angola	3748.32	7,096.60
Benin	827.84	2,122.24
Burkina Faso	645.37	1,704.86
Burundi	305.55	764.20
Cameroon	1,326.97	3,442.73
Cape Verde	3414.56	6,415.61
Central Africa Rep.	349.17	750.78
Chad	955.73	2,191.74
Comoros	1,352.13	2,663.85
Congo Democratic Republic	497.32	867.09
Congo, Rep.	1,761.32	6,089.64
Cote d'voire	1,426.46	3,444.45
Djibouti	1,787.48	4611.19
Eritrea	352.32	950.23
Ethiopia	639.30	1,621.71
Gabon	7,381.75	17,819.56
Gambia, The	649.51	1,582.20
Ghana	1,766.01	4,044.41
Guinea	769.26	1,986.17
Guniea-Bissau	603.16	1,574.46
Kenya	1336.88	2,988.07
Lesotho	1,219.18	3,062.07
Liberia	710.38	1,309.27
Madagascar	402.09	1,470.79

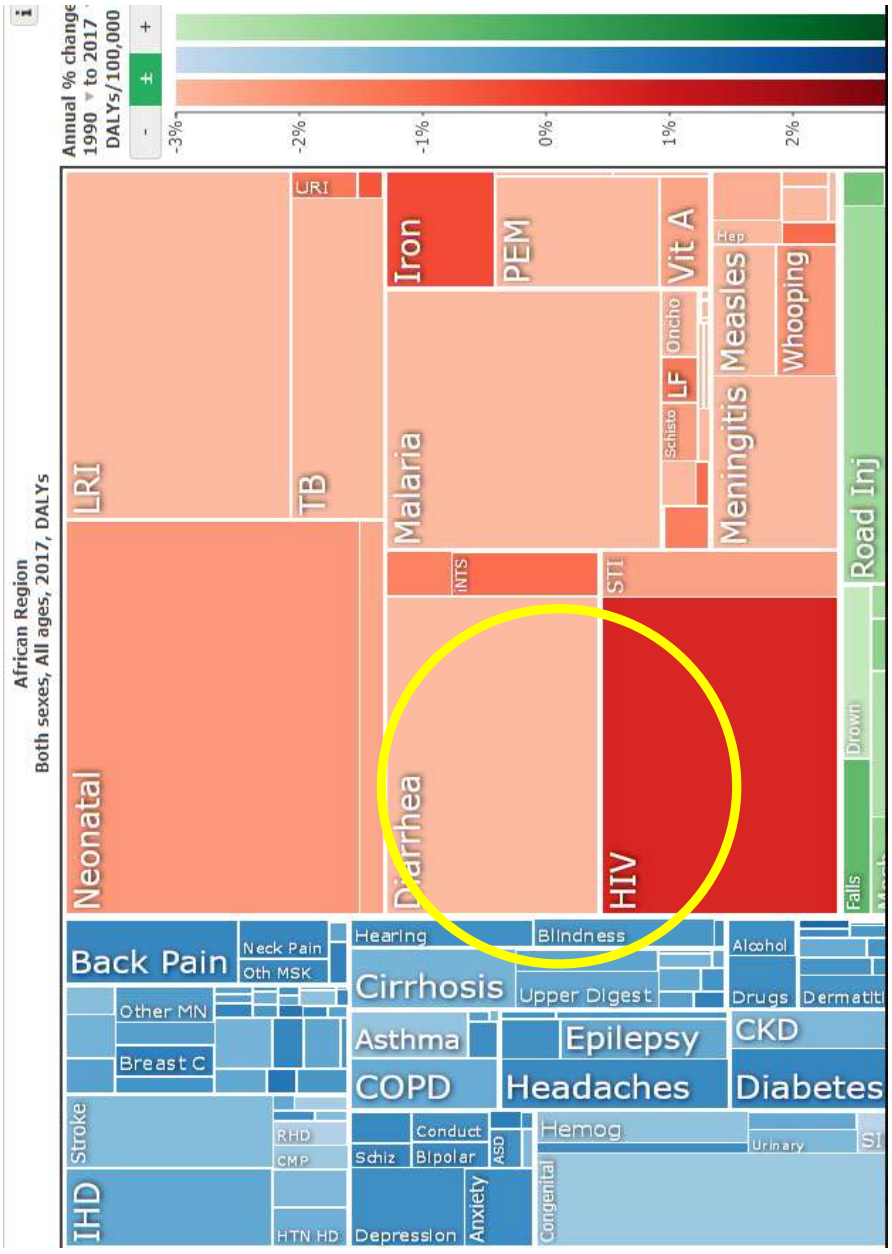
Country	GDP per capita in USD 2015	GDP per capita in INT 2015
Malawi	380.60	1220.23
Mali	751.17	2,053.13
Mauritania	1,194.31	3,975.79
Mozambique	547.24	1237.02
Namibia	5,032.89	11,160.38
Niger	360.85	964.84
Nigeria	2,730.43	6,072.48
Rwanda	728.08	1,895.11
São Tomé and Principe	1,595.86	3,086.03
Senegal	1,218.76	3,205.89
Sierra Leone	588.23	1,416.37
Somalia	483.36	
South Sudan	1154.80	2039.75
Sudan	2486.75	4552.00
Swaziland	3641.41	9899.29
Tanzania	947.93	2,791.02
Togo	570.68	1,566.99
Uganda	709.02	1,868.55
Zambia	1332.19	3927.76
Zimbambwe	1,445.07	2,679.58

Annex 2: Global burden of disease



Source: Institute for Health Metrics and Evaluation (IHME)

Annex 3: Africa Region Burden of disease



Source: Institute for Health Metrics and Evaluation (IHME)

Annex 4: Out patient costs for cholera case in Africa

		Results in US Dollars, 2008		**Results in US Dollars, 2009**		**Results in US Dollars, 2010**		
		Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)	
AFR-D	Angola	6.68	8.25	6.85	8.45	7.10	8.76	7.93
AFR-D	Benin	1.41	1.74	1.44	1.78	1.50	1.85	1.67
AFR-D	Burkina Faso	1.14	1.41	1.17	1.44	1.21	1.49	1.35
AFR-E	Burundi	0.31	0.38	0.32	0.39	0.33	0.41	0.37
AFR-D	Cameroon	2.09	2.59	2.15	2.65	2.22	2.75	2.49
AFR-D	Cape Verde	5.47	6.76	5.61	6.92	5.81	7.18	6.49
AFR-E	Central Africa Republic	0.91	1.12	0.93	1.15	0.96	1.19	1.08
AFR-D	Chad	1.40	1.73	1.43	1.77	1.49	1.84	1.66
AFR-D	Comoros	1.50	1.85	1.53	1.89	1.59	1.96	1.78
AFR-E	Congo, Democratic Republic	0.40	0.50	0.41	0.51	0.43	0.53	0.48
AFR-E	Congo, Rep	4.68	5.78	4.80	5.92	4.97	6.14	5.56
AFR-E	Cote d'voire	2.00	2.48	2.05	2.54	2.13	2.63	2.38
EMR-D	Djibouti	1.98	2.44	2.02	2.50	2.10	2.59	2.34
AFR-E	Eritrea	0.64	0.79	0.65	0.81	0.68	0.84	0.76
AFR-E	Ethiopia	0.62	0.77	0.64	0.79	0.66	0.82	0.74
AFR-D	Gabon	13.28	16.40	13.61	16.80	14.11	17.42	15.76
AFR-D	Gambia, The	0.90	1.11	0.92	1.14	0.96	1.18	1.07
AFR-D	Ghana	1.29	1.59	1.32	1.63	1.37	1.69	1.53
AFR-D	Guinea	0.73	0.90	0.75	0.92	0.77	0.96	0.86
AFR-D	Guniea-Bissau	0.60	0.74	0.62	0.76	0.64	0.79	0.71
AFR-E	Kenya	1.40	1.73	1.44	1.77	1.49	1.84	1.66
AFR-E	Lesotho	1.42	1.75	1.45	1.79	1.51	1.86	1.68
AFR-D	Liberia	0.48	0.59	0.49	0.61	0.51	0.63	0.57

		Results in US Dollars, 2008		**Results in US Dollars, 2009**		**Results in US Dollars, 2010**		
		Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)	
AFR-D	Madagascar	0.93	1.15	0.95	1.18	0.99	1.22	1.10
AFR-E	Malawi	0.54	0.67	0.55	0.68	0.57	0.71	0.64
AFR-D	Mali	1.28	1.58	1.31	1.62	1.36	1.68	1.52
AFR-D	Mauritania	1.81	2.23	1.85	2.28	1.92	2.37	2.14
AFR-E	Mozambique	0.86	1.06	0.88	1.09	0.91	1.13	1.02
AFR-E	Namibia	6.13	7.57	6.28	7.75	6.51	8.04	7.27
AFR-D	Niger	0.73	0.90	0.75	0.92	0.78	0.96	0.87
AFR-D	Nigeria	2.43	3.00	2.49	3.07	2.58	3.18	2.88
AFR-E	Rwanda	0.91	1.12	0.93	1.15	0.96	1.19	1.08
AFR-D	São Tomé and Principe	2.05	2.54	2.10	2.60	2.18	2.69	2.44
AFR-D	Senegal	1.91	2.36	1.96	2.41	2.03	2.50	2.27
AFR-D	Sierra Leone	0.69	0.85	0.71	0.87	0.73	0.91	0.82
EMR-D	Somalia			#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
AFR-E	South Sudan			0.00	0.00	0.00	0.00	0.00
EMR-D	Sudan	2.41	2.97	2.47	3.05	2.56	3.16	2.86
AFR-E	Swaziland	3.72	4.59	3.81	4.71	3.95	4.88	4.42
AFR-E	Tanzania	0.90	1.11	0.92	1.14	0.96	1.18	1.07
AFR-D	Togo	1.20	1.48	1.23	1.51	1.27	1.57	1.42
AFR-E	Uganda	0.95	1.17	0.97	1.20	1.01	1.25	1.13
AFR-E	Zambia	0.90	1.11	0.92	1.14	0.96	1.18	1.07
AFR-E	Zimbambwe	2.13	2.62	2.18	2.69	2.26	2.79	2.52

		Results in US Dollars, 2008		**Results in US Dollars, 2009**		**Results in US Dollars, 2010**		
		Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)	

	Results in US Dollars, 2008		**Results in US Dollars, 2009**		**Results in US Dollars, 2010**			
	Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)	Health Centre (no beds)	Health Centre (with beds)		
EMR-D	2.19	2.71	2.25	2.77	2.33	2.87	2.60	Somalia
AFR-D	2.27	2.81	2.33	2.88	2.41	2.98	2.70	South Sudan

Annex 5: Economic burden inputs

		Productivity loss days for patient			Productivity loss days for care givers			Hospitalization rate	Hospitalized cases USD 2015		Outpatient cases USD 2015	
		Mean	Max	Min	Mean	Max	Min		Service delivery costs	Patient/family costs	Service delivery costs	Patient/family costs
AFR-D	La-Dadekopan, Ghana (high incidence)	6.90	8.28	5.52	4.84	5.81	3.87	1.00	65.77	109.94	28.71	81.36
AFR-D	Shai Osudoku, Ghana (low incidence)	4.71	5.65	3.77	1.41	1.69	1.13	1.00	65.77	63.80	28.71	47.21
AFR-E	Zanzibar, Tanzania	5.00	6.00	4.00	3.86	4.64	3.09	1.00	72.08	13.17	53.34	9.75
AFR-E	Lusaka, Zambia	6.27	7.52	5.02	3.86	4.64	3.09	1.00	65.77	6.05	28.71	4.47
AFR-E	Malawi	8.00	9.60	6.40	4.00	4.80	3.20	0.90	85.41	13.90	3.31	2.04
AFR-E	Beira, Mozambique	3.70	4.44	2.96	5.20	6.24	4.16	1.00	39.83	26.37	29.47	19.51
	Summary	5.76	6.92	4.61	3.86	4.64	3.09	0.98	65.77	38.87	28.71	27.39
	Summary Ghana	5.81	6.97	4.64	3.13	3.75	2.50					
ALL	Average	5.76	6.92	4.61	3.86	4.64	3.09	0.98	65.77	38.87	28.71	27.39
	Maximum	8.00	9.60	6.40	5.20	6.24	4.16	1.00	85.41	109.94	53.34	81.36
	Minimum	3.70	4.44	2.96	1.41	1.69	1.13	0.90	39.83	6.05	3.31	2.04
Ghana	Average							0.98	65.77	86.87	28.71	64.28
	Maximum							1.00	85.41	109.94	53.34	81.36
	Minimum							0.90	39.83	63.80	3.31	47.21

Annex 6: GDP per capita in USD 2015 *source: IMF*

				Productivity loss			Hospitalized cases USD 2015			Outpatient cases USD 2015			http://data.worldbank.org/indicator/ISP.DYN.LEE0.IN			
	Country*	GDP per capita in USD 2015*	GDP per capita in INT 2015*	Patient	Caregiver	Proportion of hospitalization	Service delivery costs	Patient/family costs		Service delivery costs	Patient/family costs	INT$ multiplyer 2015	Life expectancy	mean age of cholera death	Year lost	Discounted years
AFR-D	**Angola**	**4354.92**	**7,411.59**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**8.65**	**6.64**	**1.701888737**	**61.241**	**22.44144423**	**38.79955577**	23.42727
AFR-D	**Benin**	**1076.91**	**2,889.47**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**1.82**	**6.64**	**2.683114698**	**60.639**	**22.44144423**	**38.19755577**	**23.23149**
AFR-D	**Burkina Faso**	**575.60**	**1,703.69**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**1.48**	**6.64**	**2.959830022**	**59.927**	**22.44144423**	**37.48555577**	**22.99491**
AFR-E	**Burundi**	**294.50**	**769.21**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.40**	**6.64**	**2.611953982**	**57.094**	**22.44144423**	**34.65255577**	**22.00466**
AFR-D	**Cameroon**	**1,338.60**	**3,468.79**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**2.71**	**6.64**	**2.591350087**	**57.582**	**22.44144423**	**35.14055577**	**22.18179**
AFR-D	Cape Verde	2996.79	6,312.93	5.94	3.80	0.97	64.72	45.25		7.09	6.64	2.106561879	72.599	22.44144423	50.15755577	26.5376
AFR-E	Central Africa Rep.	353.81	697.59	5.94	3.80	0.97	64.72	45.25		1.17	6.64	1.971668169	51.41	22.44144423	28.96855577	19.75036
AFR-D	**Chad**	**946.88**	**2,648.41**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**1.81**	**6.64**	**2.796996864**	**52.575**	**22.44144423**	**30.13355577**	**20.24348**
AFR-D	Comoros	1,259.83	2,636.93	5.94	3.80	0.97	64.72	45.25		1.94	6.64	2.093078929	63.473	22.44144423	41.03155577	24.12416
AFR-E	**Congo, Democratic Rep.**	**435.98**	**759.68**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.52**	**6.64**	**1.742476128**	**59.205**	**22.44144423**	**36.76355577**	**22.75067**
AFR-E	**Congo, Rep.**	**2,067.09**	**7,318.31**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**6.06**	**6.64**	**3.540400351**	**64.112**	**22.44144423**	**41.67055577**	**24.31435**
AFR-E	**Cote d'voire**	**1,397.30**	**3,426.85**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**2.60**	**6.64**	**1.82073579**	**53.053**	**22.44144423**	**30.61155577**	**20.44041**
EMR-D	**Djibouti**	**2,532.60**	**4,611.19**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**2.56**	**6.64**	**1.82**	**62.26**	**22.44144423**	**39.81855577**	**23.75092**
AFR-E	**Eritrea**	**352.323**	**950.234**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.83**	**6.64**	**2.697053556**	**64636**	**22.44144423**	**42.19455577**	**24.46862**
AFR-E	**Ethiopia**	**702.77**	**1,811.01**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.80**	**6.64**	**2.576973592**	**65.037**	**22.44144423**	**42.59555577**	**24.58449**
AFR-D	Gabon	7,453.11	17,970.43	5.94	3.80	0.97	64.72	45.25		17.20	6.64	2.411130167	65.685	22.44144423	43.24355577	24.76969
AFR-D	Gambia, The	649.511	2,374.85	5.94	3.80	0.97	64.72	45.25		1.17	6.64	3.656366097	60.954	22.44144423	38.51255577	23.33393
AFR-D	**Ghana**	**1,753.85**	**5,524.06**	**5.88**	**5.88**	**0.98**	**64.72**	**77.25**		**1.67**	**11.34**	**3.14967406**	**62.448**	**22.44144423**	**40.00655577**	**23.81022**
AFR-D	**Guinea**	**712.05**	**1,837.96**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.94**	**6.64**	**2.581234104**	**59.419**	**22.44144423**	**36.97755577**	**22.82451**
AFR-D	**Guinea-Bissau**	**643.92**	**1,678.85**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.78**	**6.64**	**2.60725312**	**57**	**22.44144423**	**34.55855577**	**21.97025**
AFR-E	**Kenya**	**1453.30**	**3,234.52**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**1.82**	**6.64**	**2.225645705**	**66.695**	**22.44144423**	**44.25355577**	**25.05096**
AFR-E	Lesotho	1,166.54	3,174.02	5.94	3.80	0.97	64.72	45.25		1.84	6.64	2.72087527	53.745	22.44144423	31.30355577	20.72186
AFR-D	**Liberia**	**764.41**	**1,421.48**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.62**	**6.64**	**1.859575542**	**62.007**	**22.44144423**	**39.56555577**	**23.67104**
AFR-D	Madagascar	400.35	1,469.56	5.94	3.80	0.97	64.72	45.25		1.21	6.64	3.670698992	65.539	22.44144423	43.09755577	24.72873
AFR-E	**Malawi**	**353.51**	**1129.12**	**8.00**	**4.00**	**0.92**	**77.82**	**28.60**		**0.70**	**4.20**	**3.194041419**	**62.661**	**22.44144423**	**40.21955577**	**23.87552**
AFR-D	**Mali**	**772.64**	**2,114.51**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**1.66**	**6.64**	**2.736732161**	**57.478**	**22.44144423**	**35.03655577**	**22.14483**
AFR-D	Mauritania	1,303.46	4,296.73	5.94	3.80	0.97	64.72	45.25		2.34	6.64	3.296641254	63.082	22.44144423	40.64055577	24.00458
AFR-E	**Mozambique**	**528.93**	**1194.62**	**3.70**	**5.20**	**0.98**	**47.48**	**36.91**		**1.11**	**5.42**	**2.258924554**	**57.714**	**22.44144423**	**35.27255577**	**22.2287**
AFR-E	**Namibia**	**5,160.20**	**11,319.91**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**7.94**	**6.64**	**2.193695168**	**63.782**	**22.44144423**	**41.34055577**	**24.21613**
AFR-D	**Niger**	**362.72**	**964.17**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.95**	**6.64**	**2.658318255**	**59.667**	**22.44144423**	**37.22555577**	**22.90781**
AFR-D	**Nigeria**	**2,706.34**	**6,053.50**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**3.14**	**6.64**	**2.220374201**	**52.985**	**22.44144423**	**30.54355577**	**20.41239**
AFR-E	Rwanda	736.38	1,906.57	5.94	3.80	0.97	64.72	45.25		1.18	6.64	2.5891132	66.696	22.44144423	44.25455577	25.05124
AFR-D	São Tomé and Príncipe	1,569.51	3,032.98	5.94	3.80	0.97	64.72	45.25		2.66	6.64	1.932441757	66.488	22.44144423	44.04655577	24.99458
AFR-D	Senegal	1,186.93	3,118.45	5.94	3.80	0.97	64.72	45.25		2.47	6.64	2.627337869	66.784	22.44144423	44.34255577	25.0752
AFR-D	**Sierra Leone**	**599.57**	**1,433.18**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**0.89**	**6.64**	**2.390325464**	**51.423**	**22.44144423**	**28.98155577**	**19.75605**
EMR-D	**Somalia**	**293.47**	**774.72**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**2.84**	**6.64**	**2.639911089**	**55.876**	**22.44144423**	**33.43455577**	**21.5526**
AFR-E	**South Sudan**	**1225.19**	**2001.51**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**2.94**	**6.64**	**1.633540117**	**56.322**	**22.44144423**	**33.88055577**	**21.72076**
EMR-D	**Sudan**	**1698.08**	**4281.88**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**3.12**	**6.64**	**2.521604733**	**64.257**	**22.44144423**	**41.81555577**	**24.3575**
AFR-E	Swaziland	3779.60	10038.07	5.94	3.80	0.97	64.72	45.25		4.82	6.64	2.655857837	57.107	22.44144423	34.66555577	22.00942
AFR-E	**Tanzania**	**947.90**	**2,782.17**	**5.00**	**3.86**	**0.97**	**68.93**	**28.11**		**1.17**	**4.13**	**2.935094214**	**64.95**	**22.44144423**	**42.50855577**	**24.55935**
AFR-D	**Togo**	**563.76**	**1,546.15**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**1.55**	**6.64**	**2.742570855**	**59.949**	**22.44144423**	**37.50755577**	**23.00228**
AFR-E	**Uganda**	**646.89**	**2,272.30**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**1.23**	**6.64**	**3.512635764**	**59.575**	**22.44144423**	**37.13355577**	**22.87699**
AFR-E	**Zambia**	**1310.35**	**3844.44**	**6.27**	**3.86**	**0.97**	**64.72**	**23.36**		**1.17**	**3.43**	**2.933895726**	**61.397**	**22.44144423**	**38.95555577**	**23.47801**
AFR-E	**Zimbambwe**	**1,425.01**	**2,640.59**	**5.94**	**3.80**	**0.97**	**64.72**	**45.25**		**2.75**	**6.64**	**1.852962848**	**60.398**	**22.44144423**	**37.95655577**	**23.15268**

*Denote GTFCC countries	
Mean age of cholera d	14.66216635
Min age	1
Max age	75
PERT	22.44144423

2.50
0.40
17.20